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Instrumentation in endoscopic laryngeal surgery ☆

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The development of transoral endoscopic approaches to the larynx have revolutionized the way we evaluate and treat various laryngeal pathologies. Nowadays, there is a large spectrum of laryngoscopes to address the various age groups, clinical needs, laryngeal pathologies, and subsites. The current paper is a review of some of the various laryngeal instruments used today in the evaluation and treatment of laryngeal pathologies. The review will cover some of the different means for evaluation of the larynx, various sizes and shapes of laryngoscopes, unique subsites in the larynx for which special laryngoscopes have been developed and finally will offer a number of pearls that may assist in achieving the best exposure and treatment outcomes.

Introduction

Endoscopic laryngeal surgery has revolutionized the ability to address various pathologies of the larynx. In fact, the endoscopic revolution began in the late 19th century with the combination of electrical light invented by Thomas Edison, the discovery of cocaine and the introduction of novel laryngoscopes. These inventions allowed to better understand the physiology and pathology of the larynx and eventually offered endoscopic intervention for various findings.

Nowadays, direct laryngoscopy is the main approach for laryngeal microsurgical interventions for which optimal exposure of the operative field is imperative. Laryngeal surgery demands high precision, high-magnification microscopy, appropriate laryngoscopes to view the operative field, dedicated delicate instruments to work in a narrow field and stable positioning of the surgeon's hands.

The aim of this chapter is to give an overview of some of the various laryngeal instruments used today for evaluation and surgical exposure in endoscopic laryngeal surgery. By no means can we introduce every instrument developed but offer examples of the various subgroups of instruments by their use, dedicated age group (ie, pediatric vs adult), and subsites they address. Finally, we will offer pearls to facilitate exposure of the larynx especially in those challenging situations.

Diagnostic procedures

Diagnostic procedures of the upper airway including the larynx, trachea, and main bronchi are performed in children and adults, by the use of flexible endoscopes or by rigid optical rods.

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Fiber-optic laryngoscopy is a routine safe office procedure that can be performed with or without topical anesthesia, even in the majority of children and infants. However, small children and infants may need sedation and a PICU (Pediatric Intenstive Care Unit) setting for evaluation of the airway in certain circumstances.

Flexible fiber-optic endoscopes consist of a bundle of optical fibers that may be bent at the tip and which permit large deflection angles of the distal end with an associated light source. Each fiber is kept in the same place at both ends of the bundle to allow an exact image made up of the many bundles. The resolution of the image is limited by the amount of fibers comprising the bundle. A lens system in the eyepiece provides magnification. The image is pixelated and may exhibit an insufficient resolution emphasized in particular with time when wear and tear causes inevitable brakes in the fibers that appear as black dots on the screen.

Micro laryngoscopy-bronchoscopy

Micro laryngoscopy-bronchoscopy is the term used for endoscopic evaluation of the airway performed under general anesthesia by using rigid optic rods. The advantage of rigid optical rods is in its relatively clearer view, and controlled airway setting. Naturally, a straight line of vision is mandatory and is applicable for most children and adults. Proper head position is an important parameter for achieving a nearly direct line of view of the larynx and beyond. The evaluation of the airway is performed under general anesthesia with spontaneous ventilation during which a thorough screening of the airways can be performed by using narrow rigid optical rods. A 4 mm, 0°, rod is appropriate for children and adults. Slim rods (2.2-2.9 mm) and angled view (eg, 30°, 45°) may be used in small children or in unusual anatomy. Angled endoscopes can also be used to evaluate areas that may not be readily seen through a direct line of site, such as the immediate subglottic region. The procedure can be performed by the naked eye staring down the endoscope although the standard of care today is using a CCD (charged coupled device) camera and a light source.

Rigid optical rods for the larynx

Rigid optical rods with magnification enable the clearest view of the laryngeal structures and should be used for any obscure and debatable voice disorders. Rigid optical rods differ by width (6-10 mm) and by tipped angles (ie, 70° and 90°) and are mostly coupled with a stroboscopic examination.

Video endoscopes (DC – distal chip flexible endoscopes, chip-tip endoscopes)

To overcome some of the limitations of the flexible optic fiber endoscope, video endoscopes were developed. The flexible tip contains an optical system and a digital image sensor with mini-motors that enable focusing and zooming.

Flexible endoscopes with a chip-based camera at the distal end of the scope (DC) have a better image quality than fiber-optic endoscopes, and is almost equivalent to rigid rod-lens scopes. Although the chip-tip technology has been considered a revolution in the field of endoscopy, clinical impression on several recent papers was of modest added value in terms of cost-effect and clinical needs. Light reflections are not infrequently encountered during the DC examination due to constant changes of tip position in relation with the examined surface, due to the examiner's and patient's movements (eg, respiration, swallowing, and gag reflex). Also, endoscopic sheaths covering the endoscope to prevent cross contamination significantly hamper image quality.[1,2]

Direct laryngoscopy

Laryngoscopes

The surgical laryngoscope (a metal tube) contains ports for illumination and suctioning and is stabilized by a special holder or suspension, enabling free 2-hand working through its lumen. Exposure of the vocal folds during laryngeal microsurgery via a surgical laryngoscope may pose a challenge. Patient anatomy such as with bull necks, large tongue, short jaws, prominent upper teeth etc., may impose a real challenge for the surgeon.[3] Furthermore, the location of the lesions may necessitate different instruments. For these situations a plethora of laryngoscopes, differed by size and shape, were developed to allow optimal laryngeal exposure.

It is noteworthy to mention that for the placement of an optimal laryngoscope, the patient must be in the Jackson/traditional "sniffing" position, ie, flexion of the cervical spine with relation to the thoracic spine and extension at the atlanto-occipital joint. Still, differences in opinion relating to the best position of the head, neck, and cervical spine for optimal exposure of the larynx exist.[4] In our experience, most direct laryngoscopy procedures can be satisfactorily accomplished in a recumbent position with no special head support and no assistance to position the head and neck.

Laryngoscope types

Benjamin and Lindholm reviewed the variety of laryngoscopes, the optional techniques in routine laryngoscopy, as well as in the difficult and the obstructed airway for children and adults. They classified the laryngoscopes

Figure 1 Kleinssaser laryngoscope modified by Rudert "© KARL STORZ SE & Co. KG, Germany."

Figure 2 Lindholm operating laryngoscope "© KARL STORZ SE & Co. KG, Germany."

according to differences in the desired procedures and site of intervention. Still, they also noted that many laryngoscopes are multipurpose and suitable for more than 1 application.[5]

Accordingly, several categories were suggested:

A. Diagnostic laryngoscopes (eg, Lindholm, Jackson, or Kleinsasser, in adult and pediatric sizes; Figures 1 and 2).
B. Operation laryngoscopes (eg, Dedo or Bouchayer adult and Benjamin pediatric; Figure 3).

Figure 3 Benjamin slotted laryngoscope especially appropriate for introducing pediatric bronchoscopes "© KARL STORZ SE & Co. KG, Germany."

C. Documentation laryngoscopes (eg, Kantor-Berci and Lindholm, the latter in both adult and pediatric sizes).
D. Difficult airway (eg, Benjamin Super slim-line adult and Holinger Benjamin infant).
E. The acute obstructed airway (eg, Benjamin-Parsons slotted Slimline adult and Parsons pediatric; Figure 4).
F. Transoral laser treatment (major lesions; Figure 5) and distending laryngopharyngoscopes.

Laryngoscopes can also be classified according to their capability to expose specific areas: supraglottis (eg, Steiner operating laryngoscope, Lindholm laryngoscopes); glottis (Dedo, Kleinsasser laryngoscopes); and subglottis (Benjamin subglottis scope).

Hinni and colleagues have recently developed a novel distending laryngoscope that features an anteriorly curved distal tip, distending capability, and lateral wings to protect against tongue herniation, thus incorporating the various advantages of different type of laryngoscopes.[6]

Size and shape

The widest laryngoscope that can be safely inserted into the oro-hypo-pharynx will provide the desired exposure with optimal illuminated and convenient working field. Still, inadequately large laryngoscope may prevent the exposure of the larynx or may injure the lateral boundaries of the larynx, ie, arytenoids and crico-arytenoid joints. Exposure may be gained by compromising for down-sized diameter on the expense of light intensity and stereoscopic binocular vision.

Variation in shape such as round, oval, or squared shaped laryngoscopes is aimed to improve visualization

Figure 4 Parsons Pediatric laryngoscope: flat distal end for anterior commissure, wide proximal opening enables binocular viewing, right-hand slotted for introduction of bronchoesophagoscopes and operating instruments, left-hand side with insufflation channel for oxygen supply, anesthetic gas or jet ventilation. "© KARL STORZ SE & Co. KG, Germany."

Figure 5 Steiner operating laryngoscope for transoral laser surgery "© KARL STORZ SE & Co. KG, Germany."

of the whole larynx. Widening or flaring of the proximal margins is aimed to protect the lips from laser or other injury. Widening or flaring of the distal tip is meant to improve anterior commissure exposure. Therefore, laryngoscope selection must be pragmatic.[7]

There are sets of operating laryngoscopes of several sizes each, for infants, children, and adults which allow binocular vision during microlaryngoscopy and laser surgery.

Laryngoscopes are also used for hypopharyngeal surgery and their variety and features should be tailored for each surgical purpose. A specifically-designed subglottiscope (adult or pediatric size) may be indicated for surgical intervention in the subglottic larynx.

Bivalved, geared endoscopes appear to have their best application not in regular laryngeal examination, but in distending the oropharynx and supraglottic laryngopharynx for cancer surgery or removal of a large mass.

A direct view can almost always be achieved, although with limited overall exposure through narrow-caliber laryngoscopes.

Anterior commissure exposure

Exposure of the anterior commissure is the most demanding maneuver in direct laryngoscopy and may be achieved by laryngeal dressing exerting pressure over the anterior neck. It is reasonable to assume that a triangular-like cross-section of the tip, mimicking the angle of the anterior commissure and a straight line from the proximal posterior surface of the tube will be ideal for anterior commissure exposure.[3,8]

Nevertheless, various other modifications were suggested for anterior commissure exposure, including changes in shape, ie, adding an upturned or expanded distal end, an hourglass shape or bi-valved tube.[5]

Round-shaped distal openings do not fit for the triangular angle of the glottis. Therefore, very round tubes (ie, Jako and Kleinsasser) may hamper visualization of the anterior segment of the vocal cords even under application of heavy external pressure.[3,9]

An oval opening, especially of narrow width (eg, Hollinger anterior commissure laryngoscope; Figure 6) may better accommodate the triangular glottis shape. However, laryngoscopes with flaring of the distal tip can still push the anterior commissure antero-laterally, out of sight.

Adjustable distending endoscopes, have an elongated anterior, relatively flat, blade that may be found inconvenient for anterior glottic lesions.[10]

Improved glottic exposure for robotic microlaryngeal surgery was developed using a curved-frame trans-oral system aimed for patients who cannot be operated on by standard laryngoscopes because of anatomical restrictions. It is based on using flexible instruments guided by a master-slave surgical robot in suspension laryngoscopy.[11]

Posterior commissure exposure

Optimal exposure of the posterior commissure may be gained by pressure release of the holder, anterior positioning of the tube, or by working without an endotracheal tube, eg, jet ventilation or apneic technique facilitating an unimpaired view of the operative field.

Figure 6 Holinger anterior commissure laryngoscope. "© KARL STORZ SE & Co. KG, Germany."

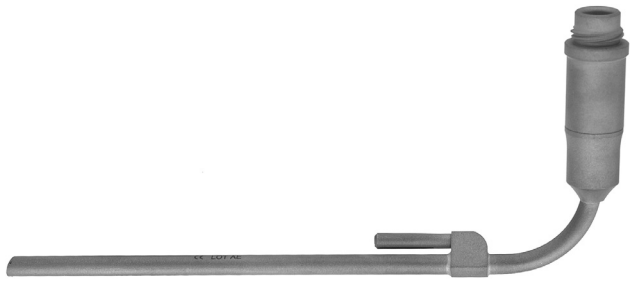

Figure 7 Fiber optic light carrier "© KARL STORZ SE & Co. KG, Germany."

Figure 8 Laryngoscope holder "© KARL STORZ SE & Co. KG, Germany."

Laryngeal pressure

To further improve visualization, the larynx may need to be manipulated by firm pressure on the neck from the fingers or hand of the examiner or an assistant. Depression of the thyroid cartilage posteriorly or to one side, while internal counter pressure is maintained with the laryngoscope will augment exposure of the anterior larynx. Constant pressure can also be maintained by placing external pressure with a gauze placed over the thyroid cartilage and silk tape pressing over the gauze while taped to both sides of the bed.

Cheng and Woo further suggested several other maneuvers to be used in case of difficult laryngeal exposure. Their protocol uses 4 techniques in escalating fashion: high-frequency positive pressure ventilation, a narrow-bore diagnostic laryngoscope with suspension, 30° and 70° telescopes with angled instruments, and a flexible laryngoscope through a laryngeal mask anesthesia (LMA) device. Each of these techniques bare its disadvantages on behalf of exposure, illumination bimanuality, and stability: these include minor increase in movement with High-frequency Positive-pressure Ventilation, loss of binocular visualization with diagnostic laryngoscopes, loss of bimanual instrument manipulation with the telescopes, and loss of stability with flexible laryngoscopy.[7]

Light sources

All laryngoscopes deliver light, either proximally by a light clip or prism or distally by a light rod (Figure 7). The light rods are introduced through integrated channels along the sides of the metal tube (laryngoscope). In the older laryngoscopes the light rod was attached to the laryngoscope by a dedicated screw on the outer (external) boundaries of the tube.

The light source may include a xenon arc lamp producing a bright white light that closely mimics natural sunlight, a halogen lamp, producing light of a higher luminous efficacy and color temperature, or LED lamps which have a lifespan and electrical efficiency of several times greater than incandescent lamps, and are significantly more efficient than most fluorescent lamps.[12]

Suspension and holders

A fixed and stable position of the laryngoscope is essential during direct laryngoscopy. Laryngoscope holding devices allow the surgeon to have both hands free and are probably the most common devices used today. The 2 basic designs for fixing the laryngoscope in a stable position are gallows suspension devices and fulcrum devices. Nowadays, holder-stabilizers use the maxilla as a fulcrum point to produce a lever force to expose the glottis. Pressure is also imposed on the dorsal tongue by the laryngoscope. An external chest bar and rod can be easily attached or detached from the handle of the laryngoscope to provide the laryngoscope the leverage needed for exposure of the anterior larynx (Figure 8).

Suspension gallows devices evolved from the Killian, Lynch devices, and allow for an elevated-vector of suspension, based on upward pressure on the tongue and mandible, while lifting the anterior pharyngeal and supraglottic tissues to reveal the glottis. These have been considered to provide superior exposure with reduced risk for

maxillary dental injury compared to fulcrum holder devices, although their use is less prevalent.[4,13]

Fixation

There are several types of self-retaining laryngoscope holders for children and adults. In all cases, the distal end should rest, securely, on a resting plate (like the "Mustard table") attached to the right side of the table. A modification like "Mayo table" may also be utilized. Emphasis should be made not to lean directly on the anterior chest wall of the patient, because it would inevitably restrict ventilation.

Teeth protection

The teeth or the gums are protected by a commercial tooth-guard, by a self-made tooth guard that can be contoured from a pliable hardened material such as Aquaplast (Qfix, Avondale, Pa, USA) or by a folded gauze. Special care is required if there are sharp, protruding, irregular teeth, gaps, dental crowns, or a bridge. Pre-made tooth guard should be recommended in patients with dental implants or bridge. Filling gaps between missing teeth by folded gauze, prior to covering with a tooth-guard may spread the pressure over the dental ridge more evenly. Introducing the laryngoscope in a somewhat oblique line through a lateral gap of missing lower premolars and molars could prevent dental injury.

Stabilization

Instrument stability has become an increasingly important requirement for successful surgery. Hand tremor is present to varying degrees in every individual, and the ability to compensate for this unintentional motion is critical for performing delicate maneuvers. Therefore, surgeon's convenience and stability are important for very delicate maneuvers or for prolonged interventions. Adjustable armrest stabilizers on a pneumatic chair, fitted for the microscope and patient's height are recommended. Table-height and tilt adjustments should be controlled by the surgeon or operating staff. Also, a u-shaped metal wire that is fixed to the endoscope was developed to allow stabilization of the long-arm micro-instruments.[14]

Pearls on surgical instruments used for improved exposure

Finally, there are a few pearls on various instruments to help facilitate exposure and handling of the various laryngeal tissues.

Self-retaining laryngeal retractors (eg, Lindholm laryngeal distending forceps) increase glottic opening and visualization of the true vocal cord area. They allow for improved anterior commissure exposure as well as superior exposure of the subglottic region.[15]

Furthermore, Bouchayer fenestrated forceps, small and large, are excellent grasping instruments allowing to gently rotate normal as well as pathologic tissue for better exposure. Suction devices with cut off control can further assist in manipulation of the tissue for better examination and exposure.

Disclosure

The authors reported no proprietary or commercial interest in any product mentioned or concept discussed in this article.

References

1. Eller R, Ginsburg M, Lurie D, et al: Flexible laryngoscopy: A comparison of fiber optic and distal chip technologies. Part 1: Vocal fold masses. J Voice 22:746–750, 2008.
2. Plaat B, Laan B, Wedman J, et al: The effect of endoscopic sheaths on visualization in distal chip and fiberoptic laryngoscopy. Head and Neck 271:2757–2760, 2014.
3. Vaughan CW: Vocal fold exposure in phonosurgery. J Voice 7(2):189–194, 1993.
4. Hochman II, Zeitels SM, Heaton JT: Analysis of the forces and position required for direct laryngoscopic exposure of the anterior vocal folds. Ann Otol Rhinol Laryngol 108:715–724, 1999.
5. Benjamin B, Lindholm C-E: Systematic direct laryngoscopy: The Lindholm laryngoscopes. Ann Otol Rhinol Laryngol 112:787–797, 2003.
6. Hinni M, Patel A, Nagel T, et al A novel distending laryngoscope: Implications in transoral surgery.. Head & Neck, 273. 2016, Berlin/Heidelberg p. 1095–1098.
7. Cheng J, Woo P: Rescue microlaryngoscopy: A protocol for utilization of four techniques in overcoming challenging exposures in microlaryngeal surgery. J Voice 26:590–595, 2012.
8. Vaughan CW Vocal fold exposure for glottic surgery via a rigid scope. 2012; http://www.bumc.bu.edu/orl/vocal-fold-exposure-for-glottic-surgery-via-a-rigid-scope/.
9. Jako GJ: Laryngoscope for microscopic observation, surgery, and photography. The development of an instrument. Arch Otolaryngol (Chicago, Ill: 1960) 91:196–199, 1970.
10. Weerda H, Pedersen P, Meuret G: A new distending laryngoscope for diagnosis and microsurgery of the larynx. Laryngoscope 93:639–641, 1983.
11. Kwon Y-S, Tae K, Yi B-J: Suspension laryngoscopy using a curved-frame trans-oral robotic system. J Interdiscip Res Dev Appl Image guided Diagnosis Therapy 9:535–540, 2014.
12. Organization IS. Anaesthetic and respiratory equipment – Laryngoscopes for tracheal intubation. In: 2015; 2:Anaesthetic and Respiratory Equipment – Laryngoscopes for Tracheal Intubation Available at: https://www.iso.org/standard/44073.html. Accessed 06/01/2019.
13. Zeitels SM, Burns JA, Dailey SH: Suspension laryngoscopy revisited. Ann Otol Rhinol Laryngol 113:16–22, 2004.
14. Armstrong WB, Karamzadeh AM, Crumley RL, et al: A novel laryngoscope instrument stabilizer for operative microlaryngoscopy. Otolaryngology 132:471–477, 2005.
15. Longstreet B, Bhama PK, Inglis AF, et al: Improved airway visualization during direct laryngoscopy using self-retaining laryngeal retractors: A quantitative study. Otolaryngology 145:270–275, 2011.